Herring Sampling Program for the Scotia - Fundy Region, 1975-1985

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HERRING SAMPLING PROGRAM IN THE SCOTIA-FUNDY REGION, 1975-85

by

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ABSTRACT

Hunt, J. J. 1987. Herring sampling program in the Scotia-Fundy Region, 1975-85. Can. MS Rep. Fish. Aquat. Sci. 1923: iii + 21 p.

Protocol and sampling design for collection of samples from the commercial herring fishery in NAFO Divisions 4VWX are described. Definition of parameters observed and conventions adopted for classification of length, weight, sex and gonadal development are also presented. A method of assigning individual fish to spawning season through subjective interpretation of maturity stage in relation to season and consideration of otolith morphology is documented. Guidelines for estimation of age based on otolith characteristics are given.

Coding formats for data are described and an inventory of samples collected, by gear type and area, for 1975-85 is presented.

RÉSUMÉ

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Le rapport décrit le protocole et le plan d'échantillonnage utilisé pour la collecte des spécimens de la pêche commerciale au hareng dans les divisions 4VWX de l'OPANO. Il présente en outre la définition des paramètres observés et des conventions adoptées pour la classification des données sur la longueur, le poids, le sexe et le développement des gonades. On explique également la méthode de répartition des poissons individuels à une saison de frai grâce à l'interprétation subjective du stade de maturité par rapport à la saison et à l'otolithométrie. Le rapport énonce aussi des lignes de conduite selon lesquelles il est possible d'évaluer l'âge des poissons d'après les caractéristiques de l'otolithe.

Enfin le rapport décrit les formats de codage ayant servi à la présentation des données, répertorie les échantillons recueillis selon la région et le genre d'engins utilisés pour la période de 1975 à 1985.

INTRODUCTION

Collection and biological analysis of herring samples from the various components of the Atlantic commercial fishery have been carried out by the Government of Canada since 1932. In recent years, this program has been the mandate of the Department of Fisheries and Oceans, Marine Fish Division at the Biological Station, St. Andrews, New Brunswick.

The overall objective of this program is to provide biological information on commercial landings for use in assessment of stock status, stock identity and other biological studies of herring. Data consist of length frequencies of fish landed and results of detailed examination of length, weight, sex, maturity stage, otolith age, gonad weight, vertebral and fin ray counts and other meristic and morphometric factors.

This report summarizes collection and field protocol, sampling designs, laboratory procedures, age determination criteria, data editing and computer formats, sample distribution and inventory for the 1975-85 period. An earlier, unpublished report provides information on the sampling program from 1982 (Simpson et al. 1982, Laboratory Reference No. 82/4, available from Department of Fisheries and Oceans, Marine Fish Division, B.I.O., Dartmouth, Nova Scotia).

FIELD COLLECTION

Herring are caught by a number of gear types in the Scotia-Fundy Region, the most important of which are purse seines, weirs and gillnets. Catches are landed directly at processing facilities or transported by truck. In recent years, a substantial foreign offshore processing facility (factory ships) has been in operation, making it necessary to collect samples at sea through the use of the International Observer Program (IOP). A recent assessment of stock status (Stephenson et al. 1986) provides a summary of the commercial herring fisheries in the NAFO Divisions 4VWX area.

The Marine Fish Division employs a number of Port Technicians within the Region, each with a responsibility to collect samples from commercial landings within a designated geographic area. Sample collection is supplemented by other Department personnel and industry workers who collect samples from remote locations or at times when staff are not available. Close liaison with industry representatives is essential in order to obtain information on fishery operations.

Samples are collected from the vessel's hold, processing plant holding tanks or vehicles used to transport fish after the sampler has verified that no culling or other potentially biasing procedures have taken place. All relevant catch information is obtained including date of capture, exact catch location, amount caught, vessel name and gear used.

To generate a length-frequency sample, from 150-200 fish are picked at random from various locations throughout the holding tank to minimize the effect of size-specific settling of fish. A length-stratified or random sample (detail sample) may also be retained and frozen for delivery to the St. Andrews laboratory at a later date. Completed sample forms are forwarded to St. Andrews on a weekly basis and arrangements are made for collection and delivery of frozen samples.

General guidelines for sampling intensity require length-frequency samples from as many vessel catches as possible with one detail sample per day per gear type per 10-min latitude and longitude square. This results in about 600 length frequency and 400 detail samples each year.

SAMPLING DESIGN

Single- and two-phase sampling designs have been used for herring, depending on intended application of the data. A single random sample of 100 fish is collected when an estimate of stock composition within a catch is necessary or when an estimate of some biological parameter with a stock is to be measured. Several stocks of herring are present in the Region which may include spring and fall spawning components and some fisheries occur in areas of stock intermixing. Estimates of age structure and stock components can then be made directly from the proportions in the random sample (cf. Doubleday and Rivard 1983).

The two-phase sampling design requires collection of a length-frequency sample of 150-200 fish and a length-stratified subsample of the length distribution. Fish are measured to the nearest half centimeter interval and the subsample is obtained by selecting the first fish encountered in each interval for lengths less than 24.5 cm and the first two fish for lengths 24.5 cm and over. This typically results in a stratified sample of 30-40 fish which is used to partition the length frequency into an age composition. Stratified samples are usually combined within temporal, geographic and gear categories to generate a key relating age or some other parameter to length and the appropriate amalgamated length frequencies partitioned using this key. Two-stage sampling accounts for approximately 85% of the samples collected and one-stage for the balance.

LABORATORY PROCEDURES

I. DATA CODING

All data collected in the field are submitted to the St. Andrews laboratory for verification, compilation and coding. Data elements to be included on the computer record are assigned a numeric code. Some elements such as sampler, weir or vessel name and amount caught are not coded and can only be determined by reference to the original hand-written copy of the sampling forms or a coded sampling inventory file which includes ancillary information.

Each sample is assigned a unique six-digit code based on geographic area of capture and consecutive number within each area. The first three digits signify the Canadian Fisheries Statistical unit area code with the first digit indicating Subarea, the second Division and the third unit area. Length-frequency and stratified samples from the same catch are assigned the same sample number. A map showing these areas is presented in Fig. 1 and the alpha numeric equivalent in Table 1.

Catch location is assigned a six-digit code based on a reference grid composed of 10-min squares of latitude and longitude. The code refers to the southeast corner of each square (for example, 451622 refers to the square located between 45°10' and 45°20' latitude and 62°20' and 62°30' longitude).

Length (mm), weight (g), sex, maturity stage and other meristic and morphometric observations are coded as in Table 3.

II. LABORATORY METHODS

Individual length, weight, sex and maturity stage are recorded for all detail samples and otoliths are removed. Additional parameters may be observed to support special studies.

Fish retained by length stratification or random sample are usually frozen but may also be in a fresh or fresh-salted condition. Frozen samples are thawed in a water bath and are assumed to return to an equivalent fresh condition, although there is some evidence to suggest shrinkage due to freezing. A study by Hunt et al. (1986) indicates an approximate 3% decrease in length. A 2% correction was applied to 1985 data prior to analysis.

Length is recorded to the nearest millimeter for the maximum overall length of the fish (defined as the length from the tip of the nose to the tip of the longest lobe of the compressed caudal fin) using a measuring board with the nose of the fish held against the head piece of the board, the fish flat against the board and the caudal fins held together.

Weight is recorded to the nearest 0.1 gram using an electronic balance tared before each fish is measured. Fish are in a "wet" condition but excess water is removed by placing them on absorbent paper prior to weighing.

Fish are opened from the vent to gill arch to allow determination of sex and maturity stage. Sex is recorded and may be coded as undetermined for very small fish. Gonad development is classified into one of eight stages ranging from immature, pre-spawning, spawning, post-spawning and resting conditions according to the criteria described in Table 4 for fish in a fresh condition. The effect of freezing may alter the characteristics to some extent as reported by Hunt et al. (1986). Hunt (1983) attempted to relate length, gonad weight, maturity stage and gonadosomatic index for herring but concluded that a subjective interpretation based on appearance had some advantage over use of a gonadosomatic index. By definition, stage VI (active spawning) requires the gonad to run freely with slight pressure although the effect of freezing may close the vent and make it difficult to assess this condition. Fish which have obviously released some reproductive material but which do not run freely are, by convention, placed in the immediate pre-spawning stage (stage V).

Otoliths are removed by making a transverse cut through the head just posterior to the eye orbit. Extraneous material is removed and the otoliths stored loose in covered plastic trays until permanently mounted in polystyrene trays with 50 depressions 1 cm by 2 mm deep per tray (from Can-Am Containers Ltd., Springhill, N.S.). Otoliths are placed side by side in the appropriate cavity of the tray with the concave side up and then covered with a 75% solution of Diatex (Canlab number M7638) in toluene delivered with a large bore glass syringe. This forms a permanent mounting medium and no further preparation is required prior to ageing. All relevant sample identification is recorded on self-adhesive labels attached to the trays.

Scales, when required, are taken from within the radius of the pectoral fin and above the mid-line of the fish. Only one scale is selected for mounting on glass microscope slides using a 50% solution of mucilage in water.

Meristic and morphometric observations may be made for some samples. At various times fin ray, vertebral and gill raker counts have been recorded. Numbers of rays in most fins (pectoral, dorsal and anal) have been observed using both visual and X-ray counts. By convention, the urostyle on the dorsal fin is excluded from X-ray counts to conform with earlier visual counts which defined the first ray as protruding through the skin, allowing tactile sensing by the recorder. The number of gill rakers is counted on the first gill arch.

Estimates of stomach volume and body cavity fat have also been made based on a subjective estimate of percent incidence using a relative scale.

III. AGE DETERMINATIONS

Estimates of age are made through subjective interpretation of otoliths to relate growth patterns to season. By convention, hyaline (translucent) zones assessed to represent overwinter growth are counted as annuli and the number of included zones equated to age-group. Year-class is therefore defined as the year of capture minus the age-group.

An arbitrary January first birthdate is assumed and the current year hyaline material found at the otolith edge is included as an annulus after this date. Studies suggest that hyaline material is formed at the periphery from early fall to late spring, making it necessary to exclude this zone from the estimate of age for fish taken in the fall and to include it for fish taken in the spring.

Fish assessed to have been spawned in the fall are assumed to have the first winter represented in the otolith by the nucleus or focus area, while spring-spawned fish are assumed to complete a nucleus plus a hyaline zone over the first winter and therefore the nucleus is excluded from the estimate of age. Assignment to spawning group is the responsibility of the age reader and is completed at the same time ages are estimated.

IV. SPAWNING GROUP ASSIGNMENT

Separation of individual fish into spawning group is based on assessment of both maturity stage in relation to season and morphological appearance of the otolith.

Maturity stage at the time of capture is used to estimate the probable season of spawning. For example, fish in an immediate pre-spawning or active spawning condition in the spring or fall are easily classified to the appropriate spawning group and, conversely, fish in a resting condition during a peak spawning period are also easily classified. Use of this method assumes: i) fish spawning in one season were themselves spawned in the same season (i.e. fish spawned in the fall will become fall spawners); and ii) maturity stage is exclusive for

different spawning groups at some times of the year. This method is of no use for immature fish. The subjective nature of stage assignment may also be a limitation since distinction between the early developing (III) and late recovering stage (VIII) is difficult but is of considerable importance for fish captured outside peak spawning periods. A generalized table has been adopted to assist in classification as follows:

Month of capture	Maturity stage	Probable spawning season
April & May	IV, V, VI, VII, VIII, III	Spring (S) Autumn (A)
June	, V, VI, VII, III, IV	S A
July	V, VI, VII, VIII III, IV, V	S A
August	III, IV, VII, VIII IV, V, VI, VII	S A
September	III, IV V, VI, VII, VIII	S A
October	III, IV V, VI, VII, VIII	S A

Overlaps exist in the table and stages are not exclusive for spawning groups. As well, the general trend within a sample is taken into consideration and, for example, a stage IV fish in a sample comprised of mostly stage V or VI collected in June would be assigned to the spring spawning group assuming spawning-group homogenity within a sample.

Otolith morphological characteristics are also used to relate juvenile growth patterns to probable date of spawning. Nucleus type and diameter, diameter of the first hyaline winter zone and general morphological shape have been used to assist assignment to spawning group. The nucleus varies from distinctly hyaline to opaque and also in diameter (Messieh 1972; Messieh and MacDougall 1985).

Diameter of the first hyaline zone is also related to spawning date. Spring-spawned fish have a relatively short growing season during the year in which they are spawned (August-September) before the onset of winter and would be expected to have a small diameter first hyaline zone. Fall-spawned fish have the entire second summer season (May-September) before the first hyaline zone is formed, suggesting a large diameter for this zone. Diameter of the first hyaline zone for spawning groups has not yet been quantified and assignment to spawning group is based on a general assessment of "large" versus "small."

Messieh (1972) measured the angle and ratio between the width of the para- and postrostral aspect of the otolith and found differences between spawning groups. The various factors, in order of significance, are listed below:

Characteristic	Description	Probable spawning group
Diameter of first hyaline zone	large small	Autumn (A) Spring (S)
Nucleus type	large hyaline small opaque	A S
Para- postrostrum ratio	<1 >1	A S
Para- postrostrum angle	<70 degrees >70 degrees	A S

V. DATA FORMATS AND EDITING

Eighty-column ASCII records are used for all herring data with separate formats for length-frequency and stratified or random samples. The first 13 fields (24 columns) are common for a length-frequency and stratified sample from the same catch. Field identifiers, column location, data type, element description and allowable range values for the two herring formats are given in Tables 2 and 3.

Prior to 1984, samples have not been formally edited although primary checks of data integrity have been carried out. A formal editing procedure was implemented in 1984, consisting of primary and secondary phases. Within samples, data elements are checked for allowable values using both range limits and reference tables relating parameters such as length and weight, age and length, spawning group and season, area of capture and fishery patterns and gear type.

VI. SAMPLING COVERAGE AND INVENTORY

Approximately 800 samples per year are collected, coded and entered to the herring sampling database. A summary for 1985, by location and sample type is given in Table 5 and presented graphically for 1975-85 in Fig. 2. Summaries for 1975-84 are available from the author. Sampling coverage of the Gulf of St. Lawrence area was taken over by the Gulf Region of the Department of Fisheries and Oceans in 1983 which accounts for the apparent lack of samples by the Scotia-Fundy Region since that time.

Minimum data in the database includes length-frequency samples and length, weight, sex, maturity stage and otolith age for all samples. Additional data such as gonad weight and meristic counts are available for some samples and other non-coded data as well as otolith material are kept on file.

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Table 1. Coding format for Canadian fisheries statistical unit areas.

Alpha numeric code	Numeric code	Alpha numeric code	Numeric code
4Tu	430	4X	460
4Tf	431	4Xm	461
4Tg	432	4Xn	462
4Th	433	4Xo	463
4Tj	434	4Xp	464
4Tk	435	4Xq	465
4Tl	436	4Xr	466
4Tm	437	4Xs	467
4Tn	438	4Xl	468
4To	439	4Xx	469
4VNa	470	5Y	510
4VS	470	5Yb	511
4VSb	472	5Yc	512
4VSc	473	5Yd	513
4VSe	474	5Ye	514
4VSv	475	5Yf	515
4W	450	5ZE	520
4Wd	451	5ZEg	521
4We	452	5ZEh	522
4Wf	453	5ZEj	523
4Wg	454	5ZEm	524
4Wh	455	5ZEn	525
4Wj	456	5ZEo	526
4Wk	457	5ZW	530
4Wl	458	5ZWq	531
4Wm	459	5ZWr	532
		5ZWs	533

Table 2. Data format, description and range values for herring length frequency records.

Field	Column	Type	Description	Allowable values
1	1-3	I3	Canadian fisheries statistical unit area	see Table 1
2	4-6	I3	Consecutive sample number starting at 001 within each unit area and generally in chronological order. Unique within a year but duplicated between years.	001-499
			Special or atypical samples start at 500	500-999
3	7-8	-	Not used	blank
4	9-10	I2	Year sample collected	00-99
5	11-12	I2	Month sample collected	01-12
6	13-14	I2	Day sample collected	01-31
7	15	I1	Not used prior to 1981	blank
			Since 1981 - length-frequency sample only	0
			- length-frequency sample with corresponding stratified or random sample	1
-	16-21	I6	Grid identification of sample location. Refers to lower right corner of the 10' latitude square such that 453605 indicates 45°30' latitude and 60°50' longitude.	
8	16-17	I2	latitude degrees	09-90
9	18	I1	tens of latitude minutes	0-5
10	19-20	I2	longitude degrees	50-71
11	21	I1	tens of longitude minutes	0-5
12	22	I1	Not used	blank
13	23	I1	Species code: Herring = 1; Mackerel = 2	1,2
14	24-25	I2	Gear used to capture fish	
			Weir	01
			Purse seine	02
			Otter trawl	03
			Shut-off net	04
			Midwater trawl	05
			Handline	06
			Trap	07
			Gillnet	08
			Drag seine	09
			Dip net	10
15	26-28	F3.1	Starting length of length frequency in 0.5 cm intervals	06.0-45.0
16+	29-80	26I2	Number of fish measured per 0.5 interval The first field indicates the number of fish at the starting length, the next field the number in the next consecutive 0.5 cm interval. If the number of fish exceeds 99 in any one interval, a second record with identical data in columns 1-25 is entered and the appropriate interval entered in fields 15 and 16+. If the number of intervals exceeds the allowed 26 per record, a second record with identical data in columns 1-25 is entered and a continuation starting length entered in fields 15 and 16+	00-99

Table 3. Data format, description and range values for herring stratified or random samples.

Field	Column	Type	Description	Allowable values
1-13	1-24		Identical to corresponding length-frequency sample	see Table 2
14	25-28	I4	Consecutive specimen number within sample	0001-0300
15	29-31	I3	Total length of fish in millimeters	060-450
16	32-35	F4.1	Fish total weight in 0.1 grams	001.0-900.0
17	36	I1	Sex Male	1
			Female	2
			Undetermined	blank
18	37-38	I2	Maturity stage undetermined	blank
			immature	01-02
			ripening 1	03
			ripening 2	04
			ripe	05
			spawning	06
			spent	07
			recovering	08
19	39-43	F5.2	Total weight of gonad	000.00-600.00
20	44	I1	Index of stomach fullness empty	0
			25% full	1
			50% full	2
			75% full	3
			100% full	4
21	45	I1	Index of body cavity fat empty	0
			25%	1
			50%	2
			75%	3
			100%	4
22	46-47	I2	Spawning group Spring	01
			Fall	blank
23	48-49	I2	Age-group of fish	00-30
24	50-51	I2	Number of vertebra	50-59
25	52-53	I2	Number of pectoral fin rays	10-22
26	54-55	I2	Number of dorsal fin rays	13-25
27	56-57	I2	Number of gill rakers	40-59
28	58-59	I2	Number of anal fin rays	10-21
29	60-61	I2	Incidence of non-specific parasites empty	0
			25%	1
			50%	2
			75%	3
			100%	4
30	62-63	I2	Number of keeled scales	10-15
-	64-80	-	Special observations unique to a sample	various

Table 4. Descriptive criteria of gonads for assignment to maturity stage.

Stage	Males	Females
I	Virgin herring. Testes very small and threadlike, whitish or grey-brown	Virgin herring. Ovaries 1-3 mm wide and wine red color
II	Virgin herring with small testes. About 3-8 mm wide and reddish grey color	Virgin herring with small ovaries. About 3-8 mm wide, eggs not visible to naked eye
III	Testes occupy about half the body cavity. About 1-2 cm and reddish grey or greyish color	Ovaries occupy about half the body cavity. Small eggs visible to naked eye. Orange color
IV	Testes almost as long as body cavity and whitish color	Ovaries almost half as long as body cavity. Larger variable size eggs, opaque, orange or yellow in color
V	Testes fill body cavity and white in color. Sperm does not flow but can be extruded	Ovaries fill body cavity and yellow color. Large round eggs with some transparent
VI	Spawning and sperm flows with little pressure	Spawning with free flowing transparent eggs
VII	Spent testes bloodshot with some residual sperm	Spent ovaries, baggy, bloodshot and empty or a few residual eggs
VIII	Recovering testes firm and larger than virgin or stage VII. Walls of testes striated, prominent blood vessels and wine red color. Progresses to Stage III	Recovering ovaries firm and larger than virgin or stage VII. Walls of ovaries striated, prominent blood vessels and wine red in color. Progresses to Stage III

Table 5. Summary of numbers of herring samples for length frequency and other parameters for 1985. Area and gear type code from Table 2. FREQ = length frequency; LEN = length; WGT = weight; MAT = maturity stage; GND = gonad weight; OTO = otolith age (similar summaries for 1975-84 available from author).

Area	Month	Gear	FREQ	LEN	WGT	SEX	MAT	GND	OTO
451	Jan	2	7381	701	701	642	642	0	701
451	Jan	5	723	196	196	0	0	0	196
451	May	8	147	0	0	0	0	0	0
451	Nov	2	347	94	94	94	94	0	94
451	Dec	2	1050	166	166	166	166	0	166
TOTAL			9648	1157	1157	902	902	0	1157
461	Jul	8	924	87	87	87	87	0	87
461	Aug	8	218	34	34	34	34	0	34
TOTAL			1142	121	121	121	121	0	121
463	May	7	475	95	95	95	95	0	95
463	Jun	7	290	103	103	103	103	0	103
463	Jul	2	559	0	0	0	0	0	0
463	Aug	8	134	35	35	35	35	0	35
TOTAL			1458	233	233	233	233	0	233
465	May	7	239	44	44	44	44	0	44
465	Jun	2	1708	86	86	86	86	80	86
465	Jun	8	180	0	0	0	0	0	0
465	Jul	2	19128	618	618	618	618	405	618
465	Aug	2	17359	1075	1075	1075	1075	632	1075
465	Aug	8	3641	196	196	196	196	43	196
465	Sep	2	1725	304	304	304	304	71	304
465	Sep	8	347	0	0	0	0	0	0
465	Oct	2	671	81	81	81	81	0	81
465	Dec	1	1167	215	215	215	215	74	215
TOTAL			46165	2619	2619	2619	2619	1305	2619
466	May	1	995	134	134	134	134	0	134
466	Jun	1	3770	455	455	455	455	0	455
466	Jul	1	5696	936	936	936	936	0	910
466	Jul	2	442	82	82	82	82	37	82
466	Aug	1	1382	285	285	285	285	15	285
466	Aug	2	4188	375	375	375	375	203	375
466	Aug	8	527	34	34	34	34	13	34
466	Sep	2	4001	706	706	706	706	131	706
466	Sep	8	5764	218	218	218	218	35	218
466	Oct	2	531	77	77	77	77	0	77
TOTAL			27296	3302	3302	3302	3302	434	3276
467	Jan	2	705	100	100	100	100	0	100
467	Jan	3	142	18	18	18	18	0	18
467	Feb	4	1017	901	601	601	601	600	601
467	Mar	3	2066	166	166	166	166	0	166
467	Apr	3	374	40	40	40	40	0	40
467	May	1	1054	94	94	94	94	0	94
467	Jun	1	476	45	45	45	45	0	45
467	Jul	1	9942	1103	1103	1103	1103	0	1103
467	Jul	2	1541	144	144	144	144	0	144
467	Aug	1	8901	1113	1113	1113	1113	0	1113
467	Aug	2	293	17	17	17	17	0	17
467	Aug	4	132	14	14	14	14	0	14
467	Sep	1	5107	778	778	778	778	0	778
467	Sep	2	887	59	59	59	59	0	59
467	Sep	4	285	70	70	70	70	0	70
467	Oct	1	4599	774	774	774	774	0	774
467	Oct	2	3174	545	545	545	545	0	545
467	Oct	4	1245	122	122	122	122	0	122
467	Nov	1	929	134	134	134	134	0	134
467	Nov	2	426	96	96	96	96	0	96
TOTAL			43295	6333	6033	6033	6033	600	5433
470	Nov	2	850	227	227	227	227	227	227
TOTAL			850	227	227	227	227	227	227

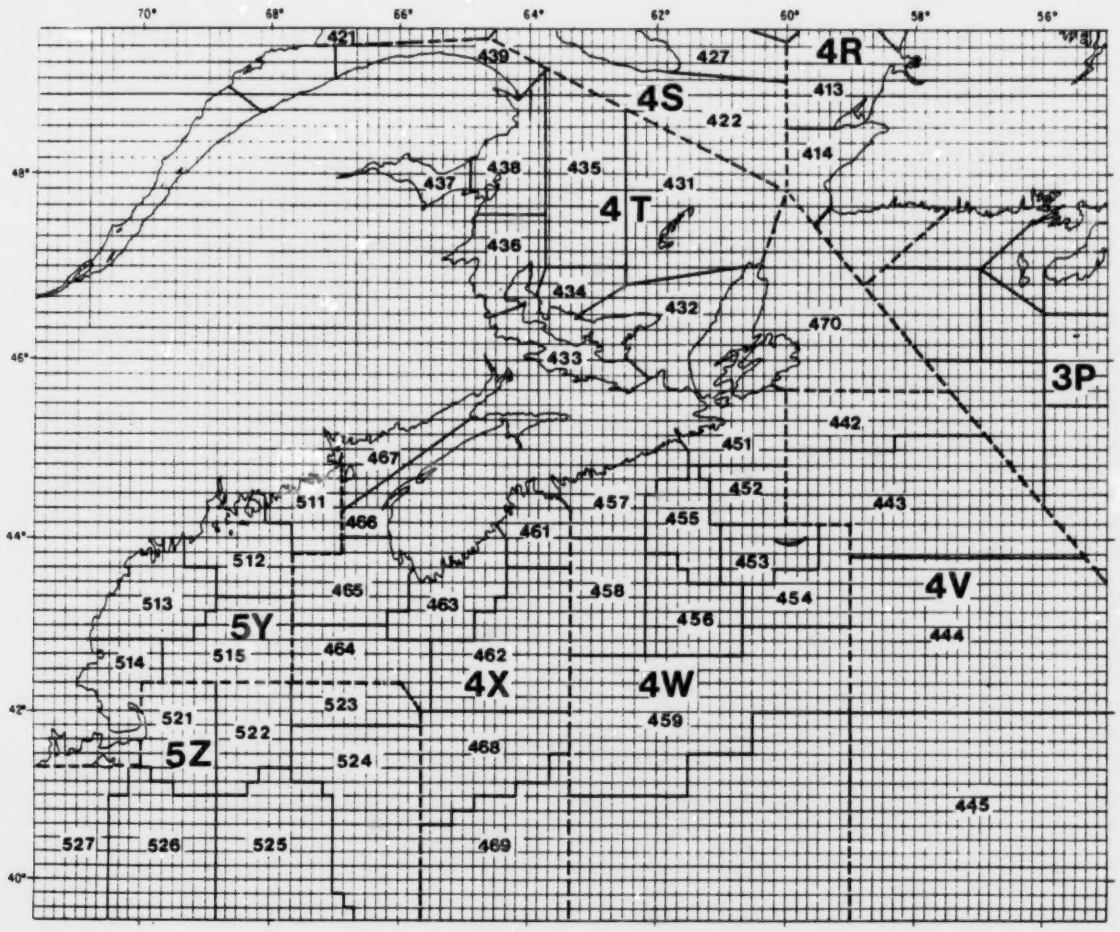


Fig. 1. NAFO Division boundaries and Canadian Fisheries Statistical unit area numeric codes, overlaid with a 10-min latitude and longitude grid.

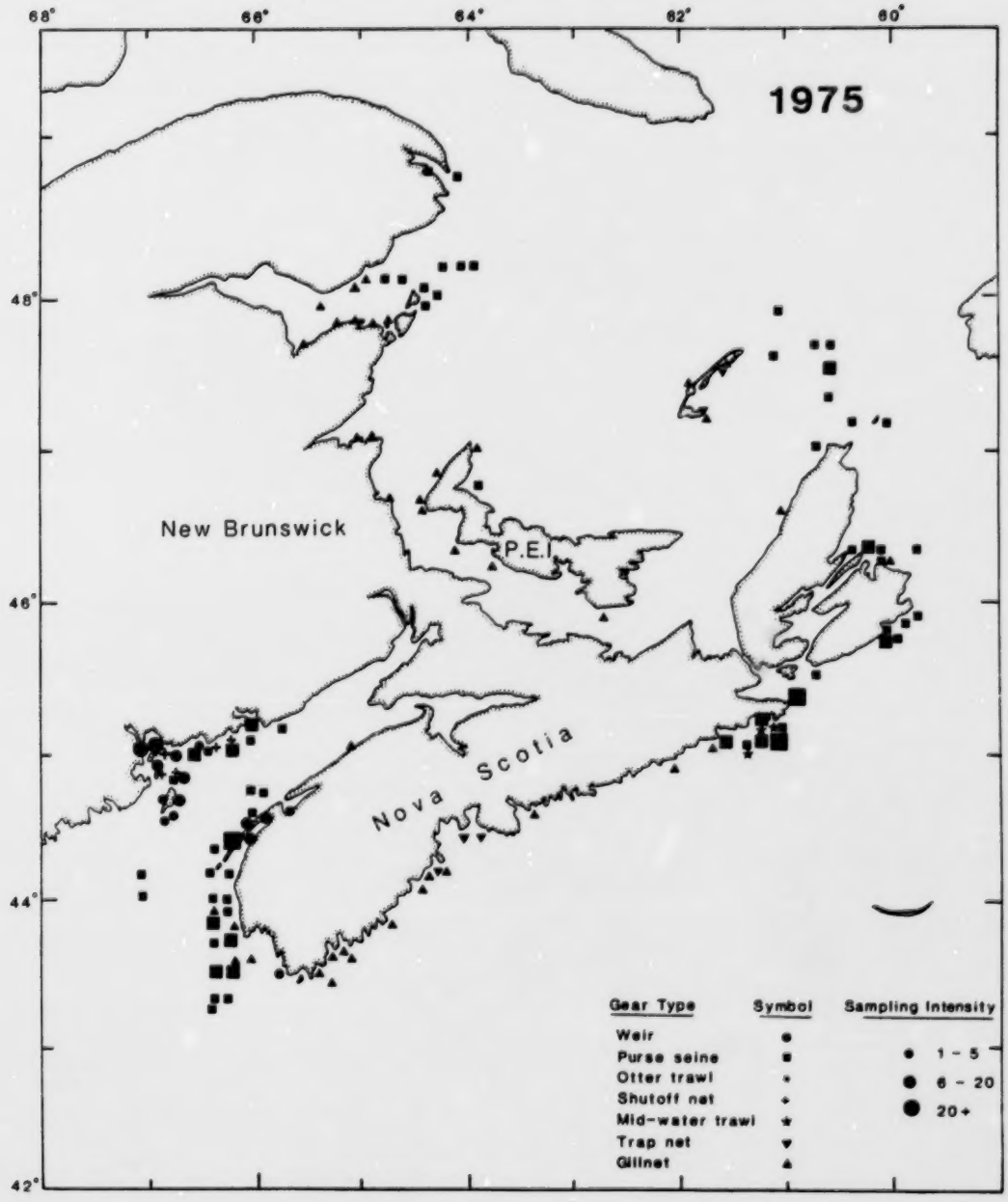


Fig. 2. Summary of herring samples collected for 1975-85, by gear type and 10-min latitude and longitude square.

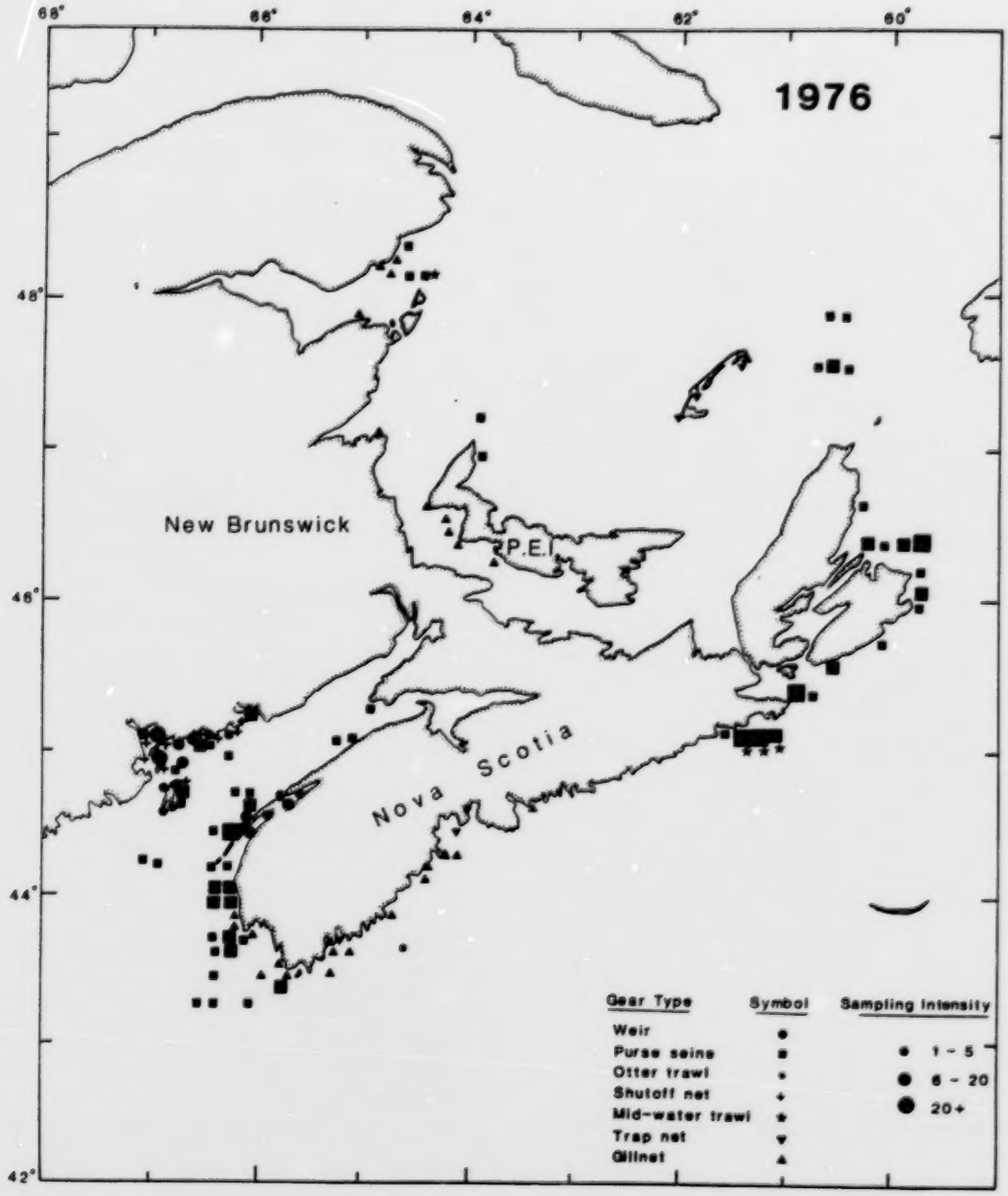


Fig. 2 (continued).

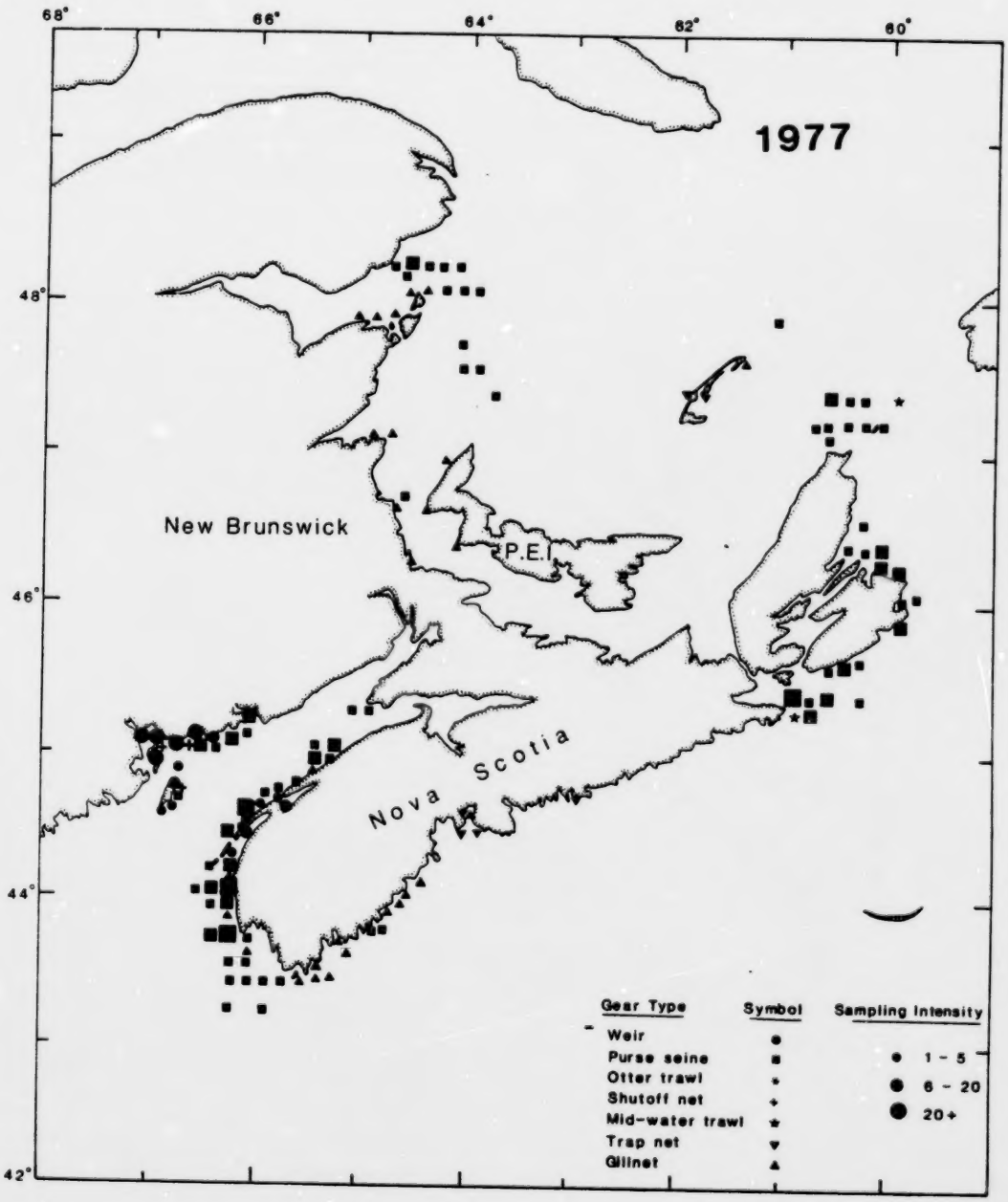


Fig. 2 (continued).

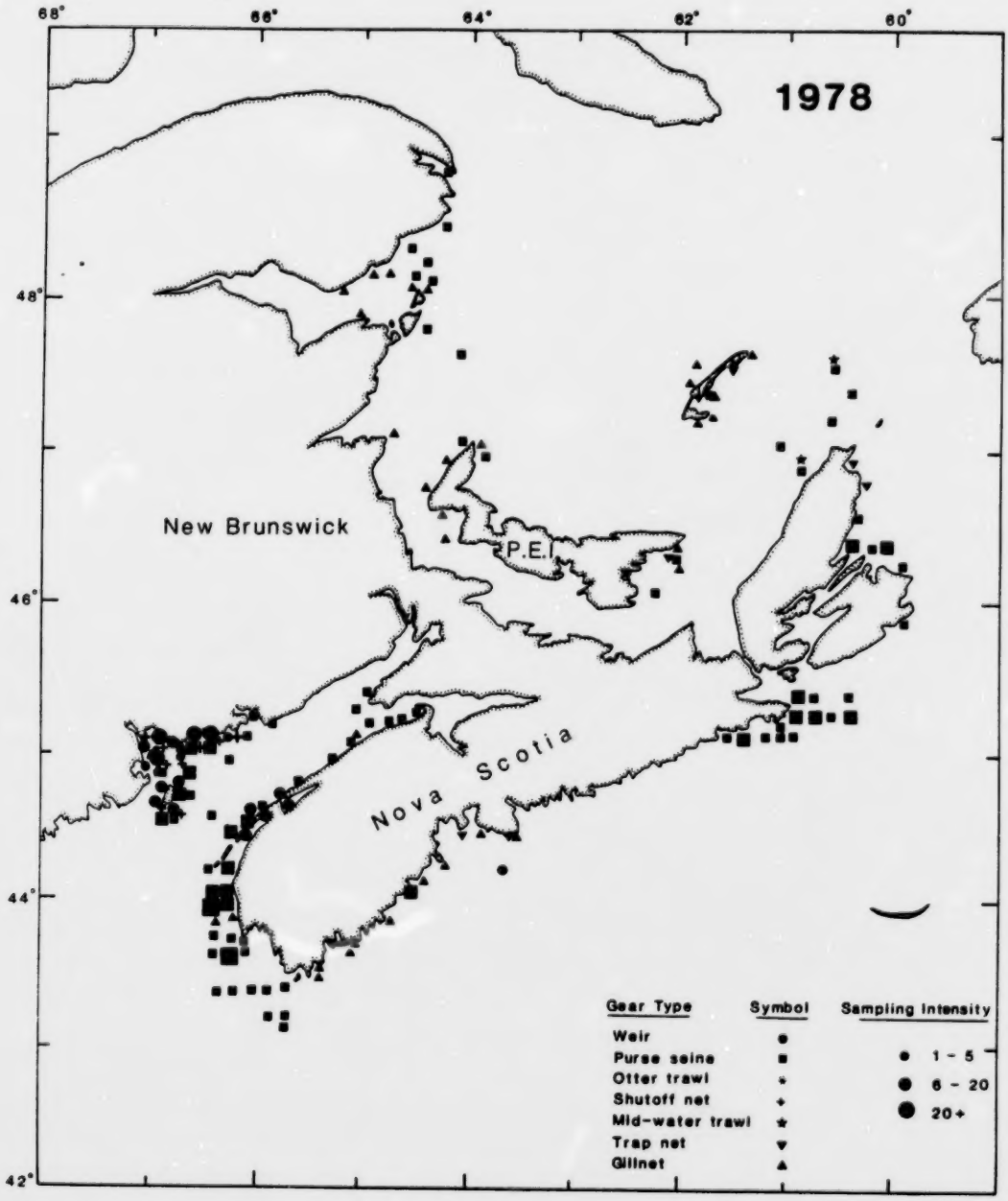


Fig. 2 (continued).

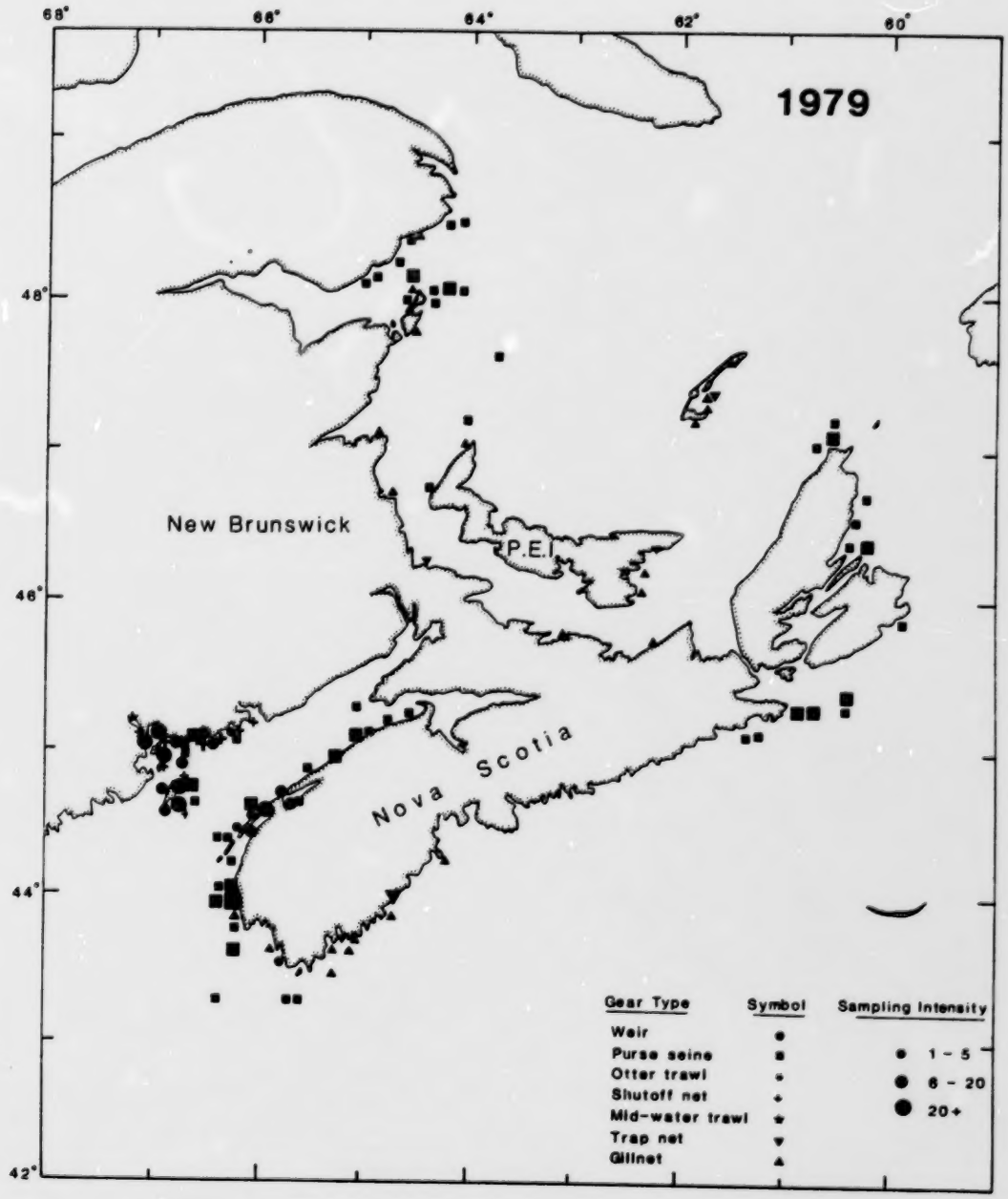


Fig. 2 (continued).

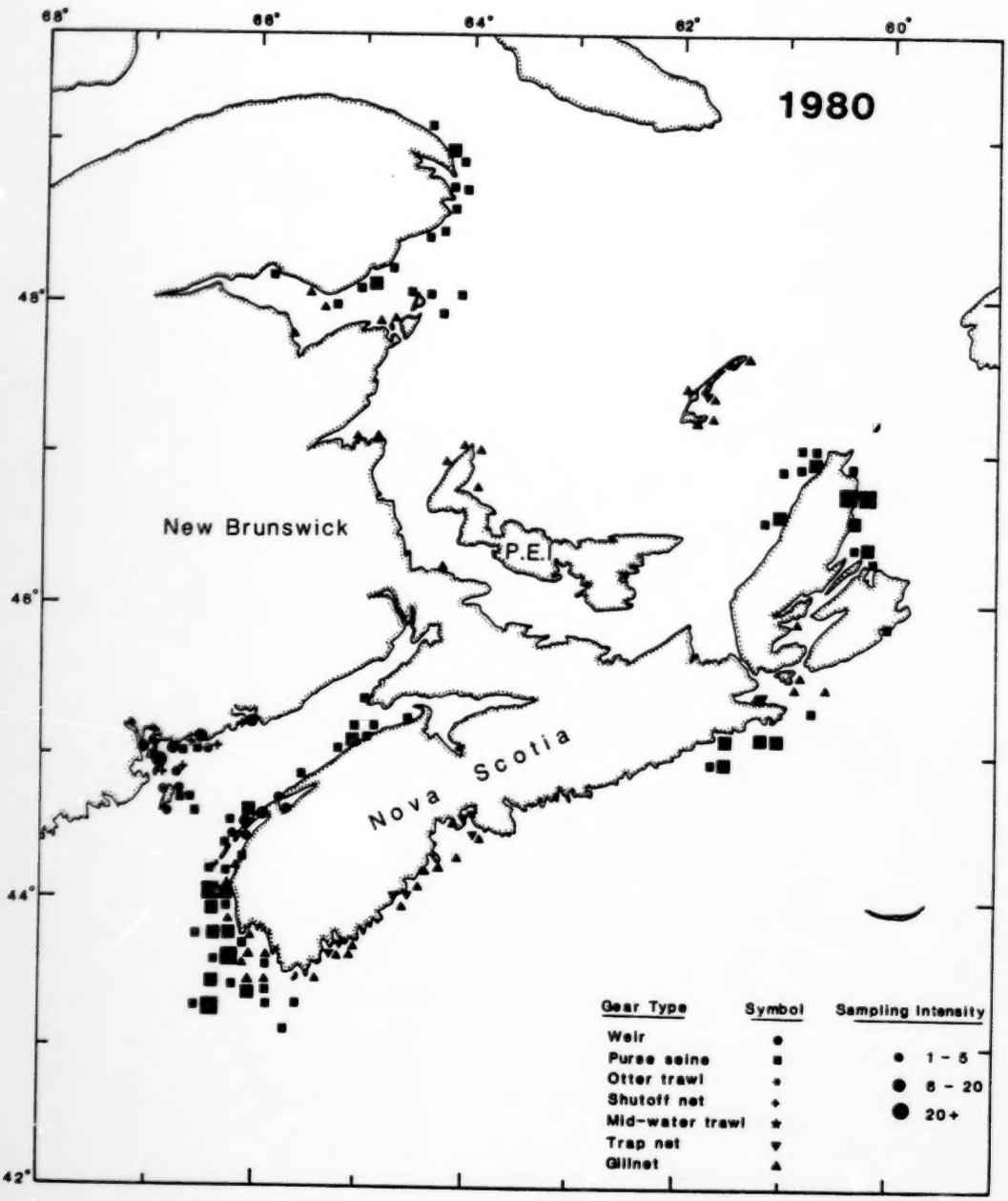


Fig. 2 (continued).

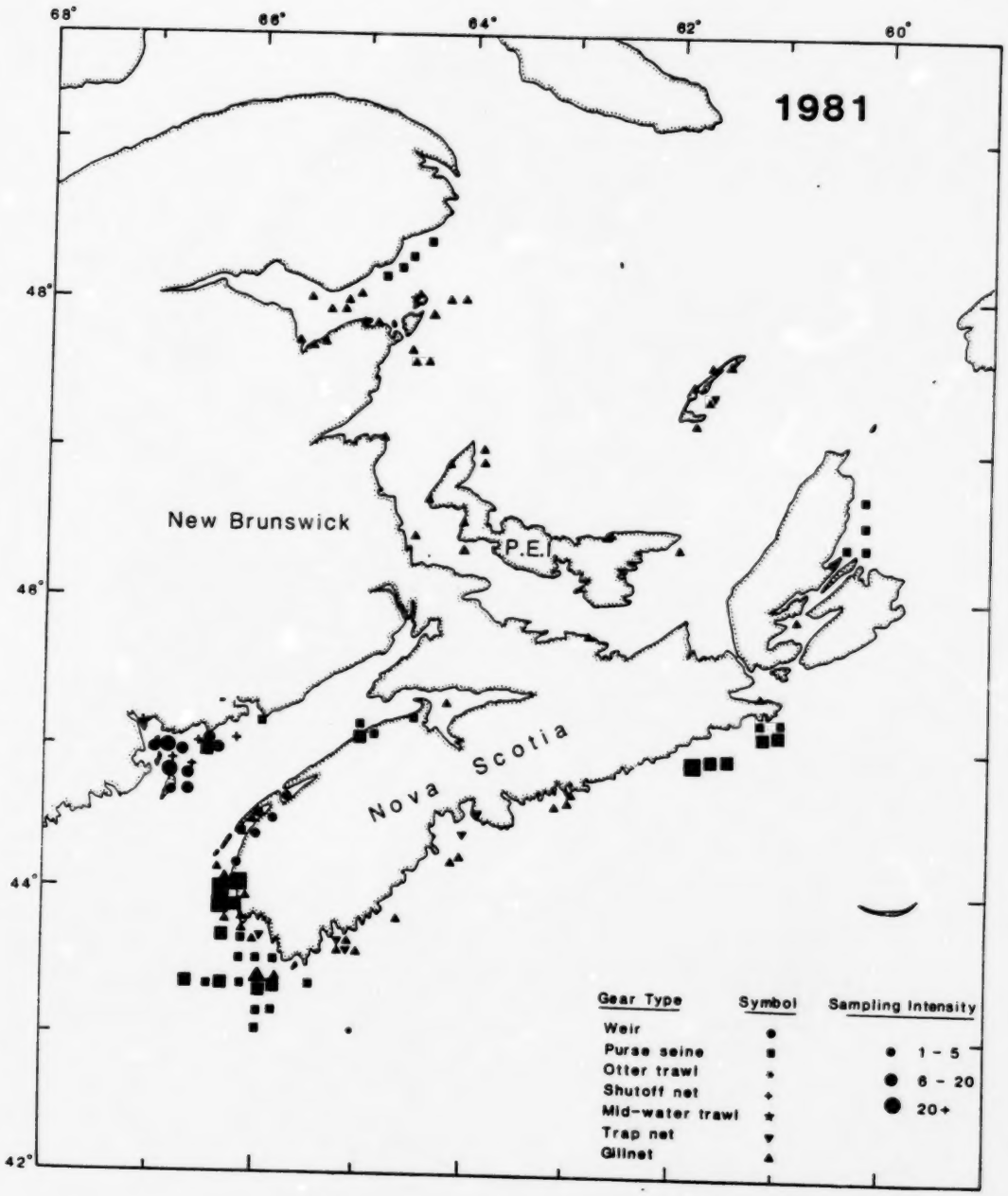
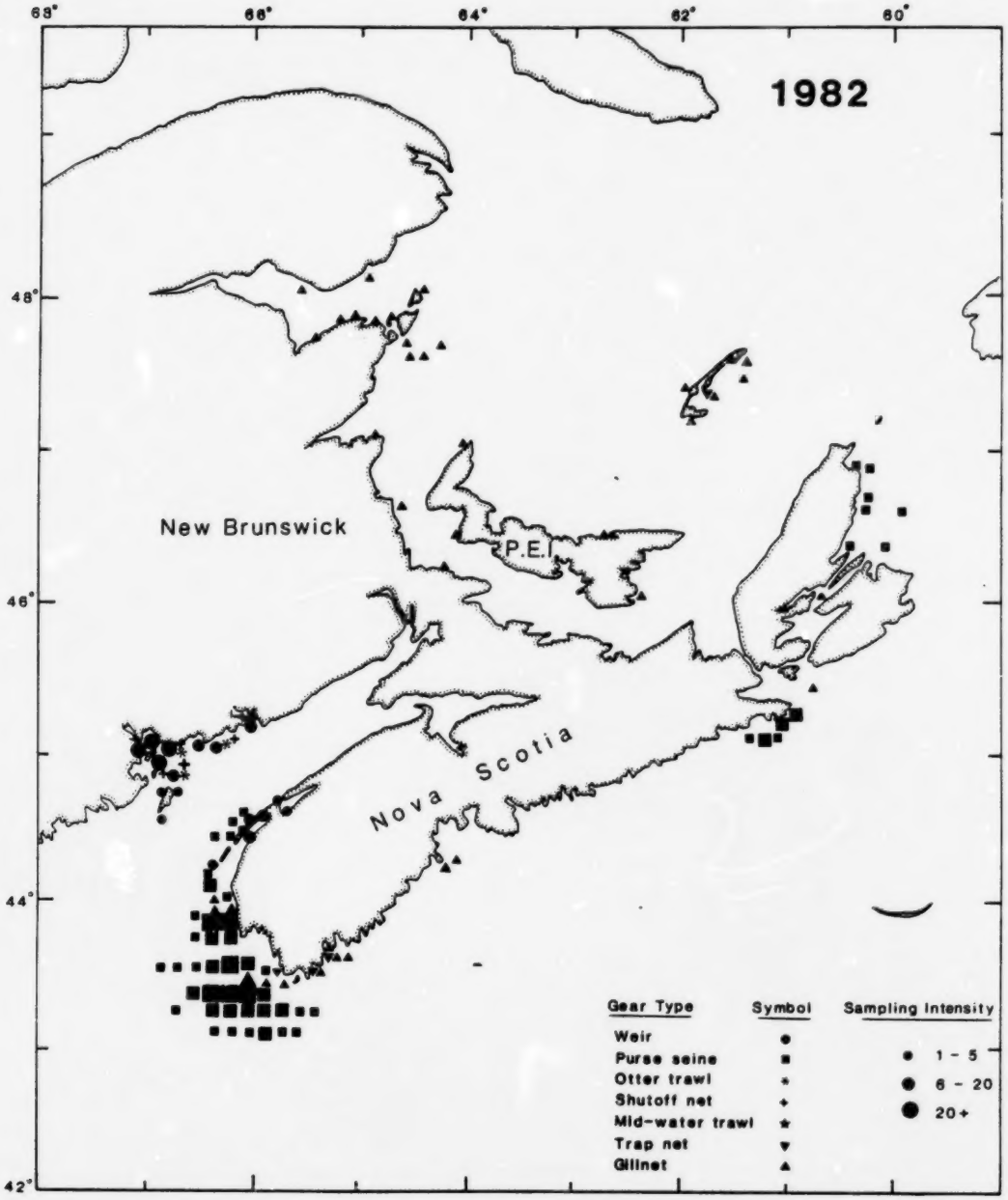


Fig. 2 (continued).



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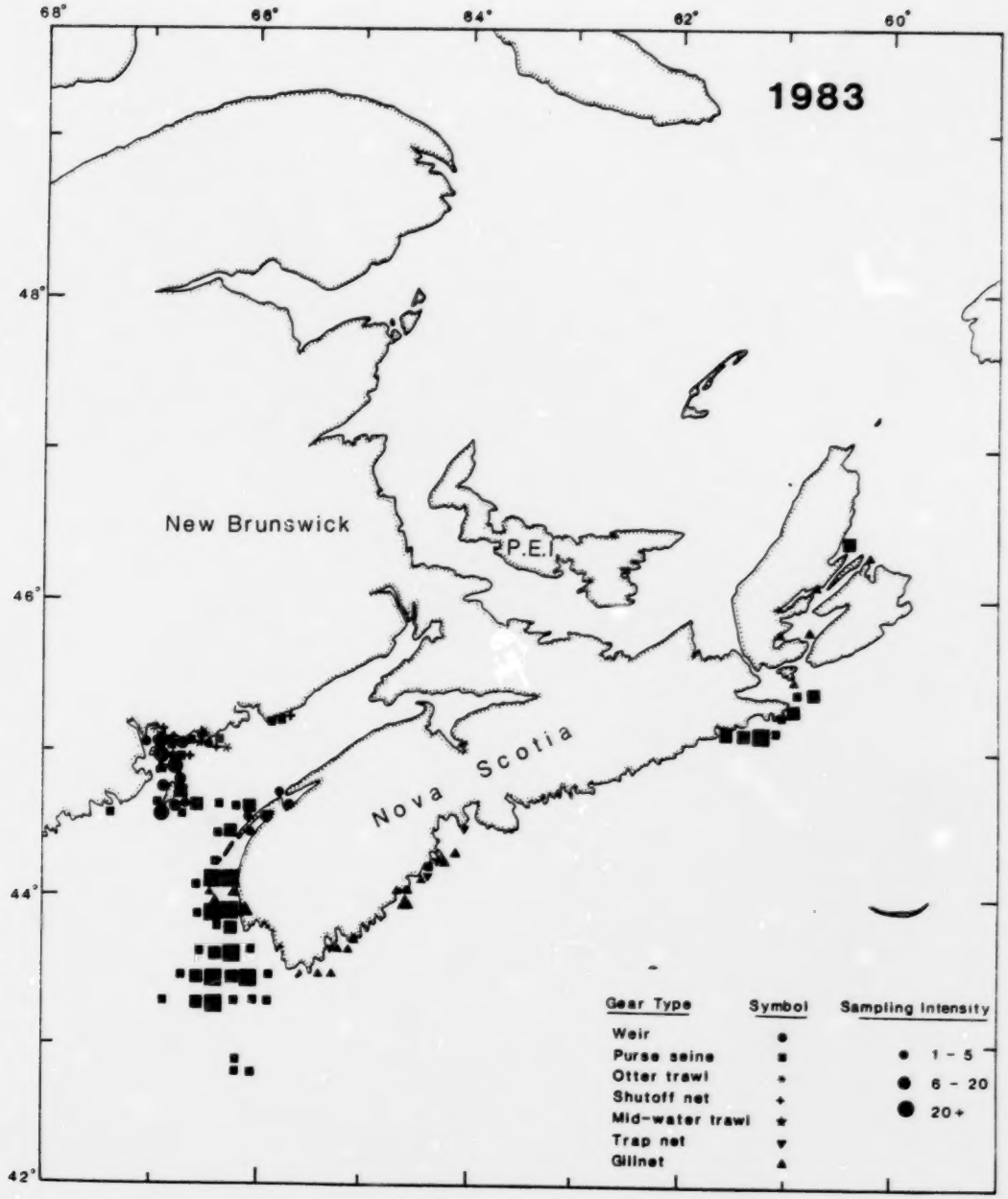

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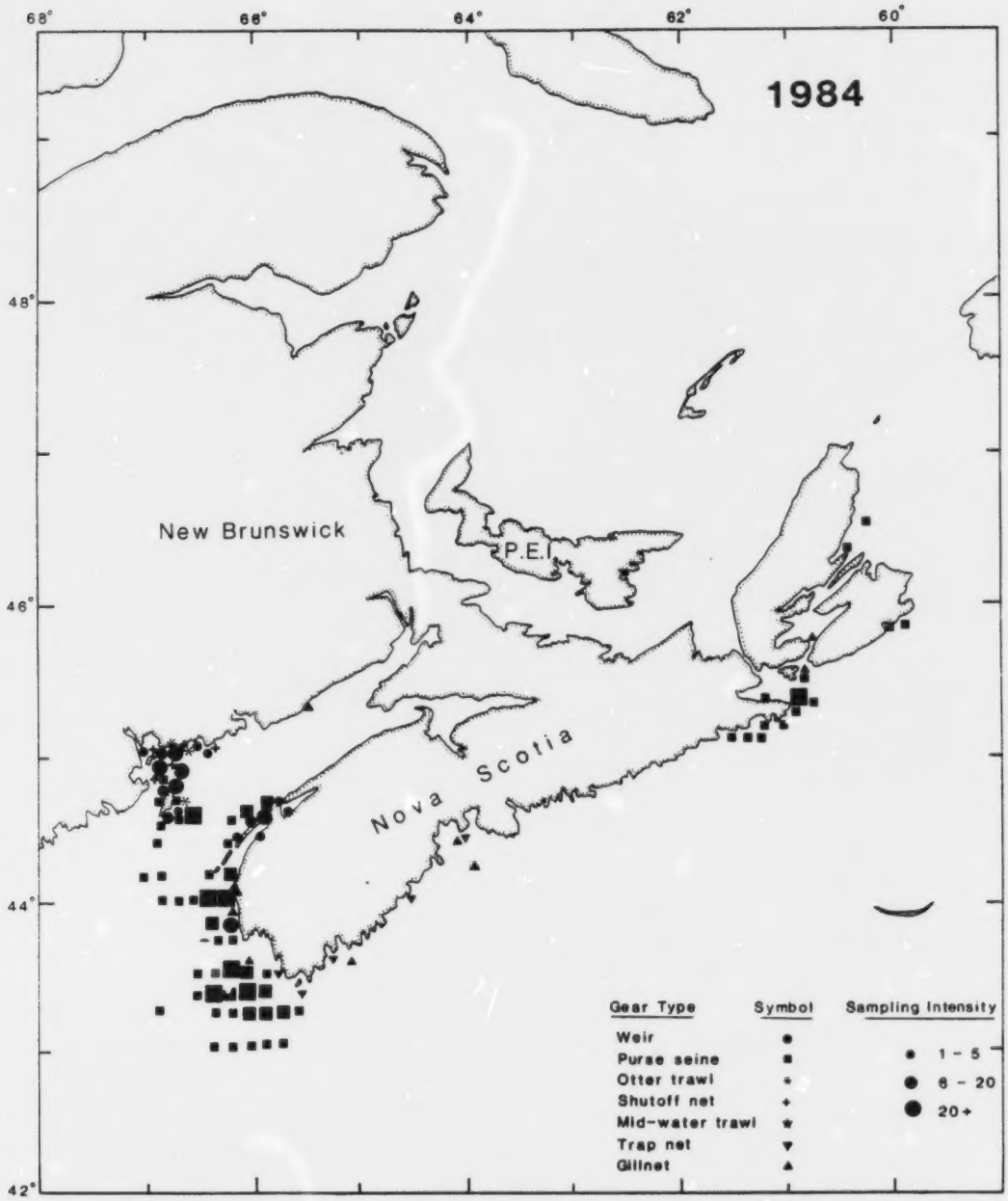

Fig. 2 (continued).

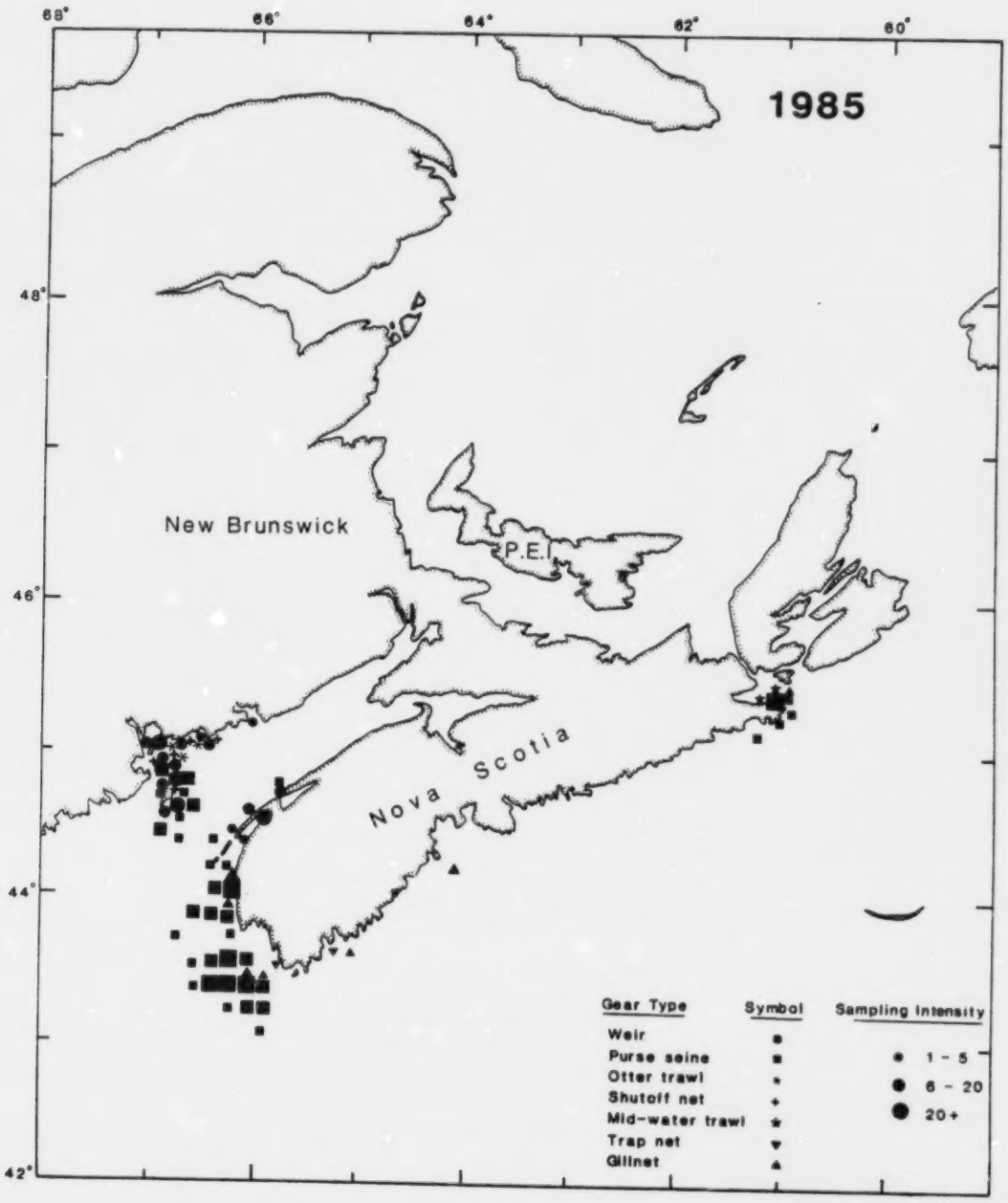

Fig. 2 (continued).